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ON-SITE AIR BAG INVESTIGATION

CASE NUMBER - IN97-035
LOCATION - ALABAMA
VEHICLE - 1994 PONTIAC GRAND PRIX
CRASH DATE - October, 1997

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The crash investigation process is an inexact science which requires that physical evidence such as skid marks, vehicular damage measurements, and occupant contact points be coupled with the investigator's expert knowledge and experience of vehicle dynamics and occupant kinematics in order to determine the pre-crash, crash, and post-crash movements of involved vehicles and occupants.

Because each crash is a unique sequence of events, generalized conclusions cannot be made concerning the crashworthiness performance of the involved vehicle(s) or their safety systems.

Technical Report Documentation Page

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15. *Supplementary Notes*
On-site air bag deployment investigation involving a 1994 Pontiac Grand Prix SE, two-door coupe, with automatic safety belts and dual front air bags; a 1987 Chevrolet S-10, pick-up truck; and a 1982 Chevrolet G-20, conversion van

16. *Abstract*

This report covers an on-site investigation of an air bag deployment crash that involved a 1994 Pontiac Grand Prix (case vehicle), a 1987 Chevrolet S-10 pickup truck, and a 1982 Chevrolet G-20 van. This crash is of special interest because the 1994 Grand Prix's unrestrained, front right passenger (6-year-old male) sustained a fatal cervical spinal cord injury from the deploying front right passenger air bag. The case vehicle was traveling south in the outside through lane of a seven-lane, divided, U.S. trafficway [i.e., both the north and southbound roadways had two through lanes, the southbound roadway also had a merging (acceleration) lane, and the northbound roadway had both right and left-hand turn lanes]. The Chevrolet pickup and the Chevrolet van had both been traveling south in the same outside through lane of the three-lane, southbound roadway. The crash occurred in the outside through lane of the southbound roadway. The front of the case vehicle struck and underrode the back of the Chevrolet pickup, knocking the pickup forward and causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Subsequently, the front of the Chevrolet pickup impacted the back of the Chevrolet van. The case vehicle's front right passenger was seated on the front of the seat cushion, and the front right seat track was located between its middle and forward-most positions. The case vehicle's front right passenger was not using his available, passive, three-point, lap-and-shoulder, safety belt system and, based on his medical records, he sustained: a laceration of his cervical spinal cord at C_2 with fracture and dislocation between C_2-C_3, a nonanatomic brain injury, a laceration of his larynx, a pneumomediastinum, fractured teeth and accompanying large full thickness laceration to his tongue, and full thickness laceration to his occipital scalp. The case vehicle's driver (18-year-old female) was seated, with her seat track located between its middle and forward-most positions, and the tilt steering wheel was located in its down-most position. She was restrained by her available, passive, three-point, lap-and-shoulder, safety belt system and sustained, according to her interview and medical records, minor abrasions and contusions to both forearms and a bruise on her right thigh. The case vehicle's back left and right passengers (12 and 11-year-old females, respectively) were seated in a non-adjustable bench seat. They were not using their available, active, three-point, lap-and-shoulder, safety belt systems. Neither back seated passenger sought medical treatment nor did they sustain any injuries as a result of this crash.

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TABLE OF CONTENTS

IN97-035

Page No.

SELECTED PHOTOGRAPHS (Continued)

BACKGROUND

IN97-035

This on-site investigation was brought to NHTSA's attention on October 14, 1997 by an NHTSA regional office. This crash involved a 1994 Pontiac Grand Prix (case vehicle), a 1987 Chevrolet S-10 pickup truck (1st other vehicle), and a 1982 Chevrolet G-20 van (2nd other vehicle). The crash occurred in October, 1997, at 3:51 p.m., in Alabama and was investigated by the applicable city police department. This crash is of special interest because the case vehicle's unrestrained, front right passenger [6-year-old, White (non-Hispanic) male] sustained a fatal cervical spinal cord injury from the deploying front right passenger air bag. This contractor inspected the scene and vehicles on October 16, 1997. This contractor interviewed the driver for the case vehicle on October 17, 1997. This report is based on the Police Crash Report, interviews with the case vehicle's driver and the investigating police officer, scene and vehicle inspections, occupant kinematic principles, occupant medical records, and this contractor's evaluation of the evidence.

SUMMARY

The case vehicle was traveling south in the outside through lane of a seven-lane, divided, U.S. trafficway and intended to continue traveling south [i.e., both the north and southbound roadways had two through lanes, the southbound roadway also had a merging (acceleration) lane, and the northbound roadway had both right and left-hand turn lanes]. The Chevrolet pickup and the Chevrolet van had both been traveling south in the outside through lane of the same three-lane, southbound roadway and had just come to an abrupt stop because of traffic ahead. The case vehicle's driver braked, attempting to avoid the crash. The crash occurred in the outside southbound through lane of the southbound roadway; see **CRASH DIAGRAM** below.

The front of the case vehicle struck and underrode the back of the Chevrolet pickup, knocking the pickup forward and causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Subsequently, the front of the Chevrolet pickup impacted the back of the Chevrolet van. The case vehicle came to rest in the outside southbound through lane near the initial point of impact heading south. The Chevrolet pickup also came to rest heading south in the same lane but near its point of impact with the Chevrolet van. The driver of the Chevrolet van drove the van ahead and into the merging lane where the driver parked the van.

The case vehicle's front right passenger [124 centimeters and 22 kilograms (49 inches, 48 pounds)] was not using his available, passive, three-point, lap-and-shoulder, safety belt system. In addition, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body, and the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of his available safety belts, the front right passenger moved forward and slightly upward just prior to impact. The damage on the case vehicle was primarily above the bumper resembling an underride impact pattern. The underride type damage resulted in the air bag deploying late during the duration of the impact. This late deployment occurred due

to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). The case vehicle's underride-type impact with Chevrolet pickup enabled the case vehicle's front right passenger to continue forward and upward as the case vehicle decelerated. Although the front right passenger attempted to brace himself with his hands just prior to the crash, the delayed deployment coupled with the front right seat's track location and the front right passenger's forward position in the seat enabled the front right passenger to be very close to the front right air bag module just prior to the deployment. Based on the available injury evidence, the front right air bag module's cover flap most likely missed the front right passenger, but he contacted the front left surface of the deploying air bag, most likely with his chin and neck areas. As the air bag continued to expand combined with the front right passenger's forward momentum, he was redirected slightly upward contacting the middle of the right windshield with his face and/or anterior scalp. As the air bag expanded further, the deploying air bag lifted him upwards where he contacted the windshield's front header and sun visor with the occipital area of his scalp, separating the glazing from the header (i.e., a clump of hair was stuck in the header between header and glazing). The front right passenger subsequently rebounded backwards and to his left where his head skimmed the roof, depositing a blood smear. The child most likely contacted the left side of the front right seat back before landing on the front right seat and falling leftward into the driver's lap. At final rest, the front right passenger had his head on driver's right thigh with his torso over the center console and his legs sticking out towards the right instrument panel.

The front right occupant was transported by ambulance to the hospital. He sustained fatal injuries but was hospitalized and subsequently pronounced dead approximately nine hours post-crash. Based on this occupant's medical records (no post-mortem examination was performed), the injuries sustained by the case vehicle's front right passenger included: a laceration of his cervical spinal cord at C_2 with fracture and dislocation between C_2-C_3, a nonanatomic brain injury, a laceration (transection) of his larynx, a pneumomediastinum, fractured teeth and accompanying large full thickness laceration to his tongue, and full thickness laceration to his occipital scalp. This occupant's primary brain, neck, and fatal cervical injuries were caused by his contact with the case vehicle's deploying front right passenger air bag.

The 1994 Pontiac Grand Prix SE was a front wheel drive, two-door coupe (VIN: 1G2WJ12M4RF------). The case vehicle was equipped with anti-lock brakes. The 1987 Chevrolet S-10 is a rear wheel drive, two-door pickup truck (VIN: 1GCCS14R4H2------). The 1982 Chevrolet G-20 is a rear wheel drive, ¾-ton, full sized van (VIN: 1GCEG25H2C7------). The case vehicle and Chevrolet pickup were both towed due to damage, while Chevrolet van was driven from the scene. Based on the vehicle inspection and available photographs, the CDCs were determined to be: **12-FDEW-1 (0)** for the case vehicle [maximum crush was 18 centimeters (7.1 inches) above bumper at C_1], **06-BDLW-1 (180)** and **12-FDEW-1 (0)** for the Chevrolet pickup [maximum crush for the initial impact was 35 centimeters (13.8 inches) at C_5], and **06-BYMW-1 (180)** for the Chevrolet van which had no visible deformation in the on-scene police photographs. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta V's are, respectively: 22.8 km.p.h. (14.2 m.p.h.), -22.8 km.p.h. (-14.2 m.p.h.), and 0 km.p.h. (0 m.p.h). Because of the underride-type impact, these results, although, reasonable, should be considered suspect.

The case vehicle's driver air bag was located in the steering wheel hub. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed without any tethers. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 63 centimeters (24.8 inches) and a width of approximately 59 centimeters (23.2 inches). An inspection of the driver's air bag revealed blood smears all over (i.e., in all four quadrants) the front surface of the air bag's fabric. These blood smears are most likely from the front right passenger.

The front right passenger's air bag was located in the top of the instrument panel. An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flap opened at the designated tear points, and there was a scuff, a pencil indentation, and what appeared to be skin on the front right air bag module's cover flap. In addition, the front right corner and right side of the cover flap contacted the windshield fracturing it and abrading the right side of the flap. The front right passenger's air bag was designed with two tethers, each 8 centimeters (3.1 inches) in width. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag was rectangular with a height of approximately 47 centimeters (18.5 inches) and a width of approximately 70 centimeters (27.6 inches). An inspection of the front right air bag revealed a large amount of skin on the front left portion and some transfer marks from the backside of the cover flap located to the left of the skin evidence.

Inspection of the case vehicle's interior revealed an oil smudge and hair in the center of the right windshield's glazing, a skin transfer on the glove compartment's door, an indentation and hair on the front right header, an oil smudge at the junction of the right "A"-pillar and windshield, blood drops on the roof just behind the rearview mirror and over the front right passenger seating area, and blood on the driver's seat cushion, particularly along the right side of the cushion near the center console near where the front right passenger's head came to rest. In addition, there was a blood smear on the driver's seat belt webbing and the left "B"-pillar that was most likely deposited by the driver after she touched the front right passenger and exited the vehicle.

Immediately prior to the crash the case vehicle's front right passenger (i.e., brother of driver) was seated leaning forward on the forward-most edge of the seat cushion with his back forward of the seat back, his feet hanging down, and both arms reaching out toward the right instrument panel bracing for the impact. The front right passenger was holding a children's giant oversize pencil in his right hand just prior to the crash. The pencil point apparently contacted the cover flap as the front right passenger moved forward, and the front right passenger may have contacted the cover flap with his hand/wrist/forearm as a result; however, there are no reported lesions consistent with cover flap interaction. The front right seat track was located between its middle and forward-most positions, and the seat back was slightly reclined.

Immediately prior to the crash the case vehicle's driver [sister of front right passenger; 18-year-old, White (non-Hispanic) female; 168 centimeters and 57 kilograms (66 inches, 125

pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel at the 9 and 3 o'clock positions. Her seat track was located between its middle and forward-most positions, the seat back was slightly reclined, and the tilt steering wheel was located in its down-most position. The case vehicle's driver was using her available, passive, three-point, lap-and-shoulder, safety belt system. The inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading as well as blood smears on the webbing and near the latch plate.

The case vehicle's driver was transported by ambulance to the hospital. She sustained minor injuries and was treated and released. The injuries sustained by the case vehicle's driver included: abrasions and contusions to both forearms and a bruise on her right thigh.

The case vehicle's back left passenger [i.e., sister of driver; 12-year-old, White (non-Hispanic) female; 155 centimeters and 42 kilograms (61 inches, 93 pounds)] was seated upright with her back against the seat back, both feet on the floor, and both hands on her lap. The seat track and seat back were non-adjustable. The back left passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back left passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the webbing.

The case vehicle's back right passenger [11-year-old, White (non-Hispanic) female; 150 centimeters and 39 kilograms (59 inches, 85 pounds)] was seated upright with her back against the seat back, both feet on the floor, and both hands on her lap. The seat track and seat backs were non-adjustable. The back right passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the webbing.

Both back seat passengers were driven from the scene by an older sibling of the back left passenger. No medical treatment was sought since neither sustained any injuries as a result of this crash.

CRASH CIRCUMSTANCES

The case vehicle was traveling south in the outside through lane of a seven-lane, divided, U.S. trafficway and intended to continue traveling south [i.e., both the north and southbound roadways had two through lanes, the southbound roadway also had a merging (acceleration) lane, and the northbound roadway had both right and left-hand turn lanes]. The Chevrolet pickup and the Chevrolet van had both been traveling south in the outside through lane of the same three-lane, southbound roadway and had just come to an abrupt stop because of traffic ahead (**Figure 1**). According to our interview with the case vehicle's driver, she noticed flashing lights from a police car ahead and became preoccupied with getting the front right passenger off the floor and back into his seat so that the child could put on his seat belt. This distraction resulted in the driver braking in an attempt to avoid the crash. The crash occurred in the outside southbound through lane of the southbound roadway (**Figure 2**); see **CRASH DIAGRAM** below.

Figure 1: Southward travel path in outside southbound travel lane for all three involved vehicles–case vehicle, Chevrolet pickup, and Chevrolet van (case photo #03)

Figure 2: On-scene view showing final rest positions for case vehicle (red coupe) and Chevrolet pickup (white) in outside southbound through lane; Note: Chevrolet van (arrow) was driven ahead to rest in southbound merging lane (case photo #04)

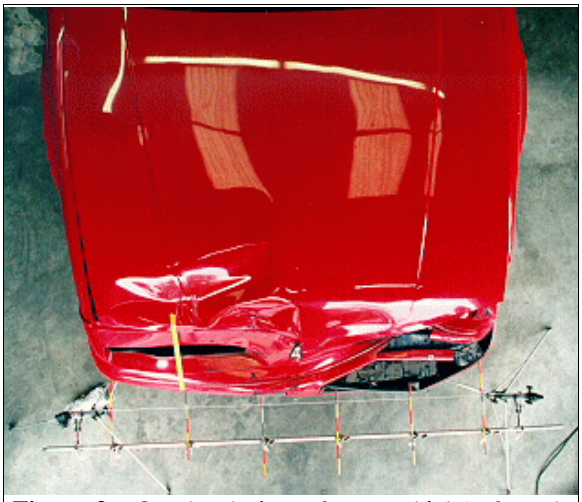

Figure 3: Overhead view of case vehicle's frontal damage with contour gauge present (case photo #11)

The U.S. highway was straight and had a 5.4% grade negative to the south at the area of impact (i.e., a downgrade in all three of the involved vehicle's direction of travel). The pavement was bituminous, but traveled, and the width of the outside southbound travel lane for all three vehicles was 3.5 meters (11.6 feet), the inside southbound through lane was 3.7 meters (12.1 feet), and the merging lane was 3.8 meters (12.5 feet). At the area of the crash, the shoulders were improved (i.e., bituminous). There was a small paved shoulder adjacent to a bituminous barrier curb on the west side of the southbound roadway (i.e., on the west side only and only at the area of the crash). The east side had a smaller paved shoulder which was bordered by a mountable curb, prior to the 2.8 meter (9.2 foot) wide unprotected grassy median (**Figure 1** above). Pavement markings consisted of single broken white lane lines that separated the two through lanes and the one merging lane from one another. In addition, the roadway was bordered by a solid yellow edge line on the east side and a solid white edge line on west side (at the area of impact). The estimated coefficient of friction was 0.65. There were no visible traffic controls in the southbound travel direction, but all three vehicle's had just passed through a four-leg intersection, controlled by on-colors, pre-timed, vertically-mounted, traffic control signals. The legal speed limit was 64 km.p.h. (40 m.p.h.). At the time of the crash the light condition was daylight, the atmospheric condition was cloudy, and the road pavement was dry. Traffic density was heavy, and the site of the crash was urban commercial with a galleria (mall) nearby.

The front (**Figure 3** above and **Figures 4** and **5**) of the case vehicle struck and underrode the back (**Figure 2** above and **Figures 6** and **7**) of the Chevrolet pickup, knocking the pickup forward and causing the case vehicle's driver and front right passenger supplemental restraints (air bags) to deploy. Subsequently, the front of the Chevrolet pickup impacted the back of the Chevrolet van. The case vehicle came to rest in the outside southbound through lane near the

initial point of impact heading south. The Chevrolet pickup also came to rest heading south in the same lane but near its point of impact with the Chevrolet van. The driver of the Chevrolet van drove the van ahead and into the merging lane where the driver parked the van (**Figure 2** above).

Figure 4: On-scene view of case vehicle at final rest; Note: damage to right half of hood and right windshield's glazing (case photo #09)

Figure 5: Case vehicle's frontal damage viewed from left of front with contour gauge present; Note: yellow tape indicates end of direct damage width (case photo #12)

Figure 6: On-scene photo of Chevrolet pickup's damaged back (case photo #56a)

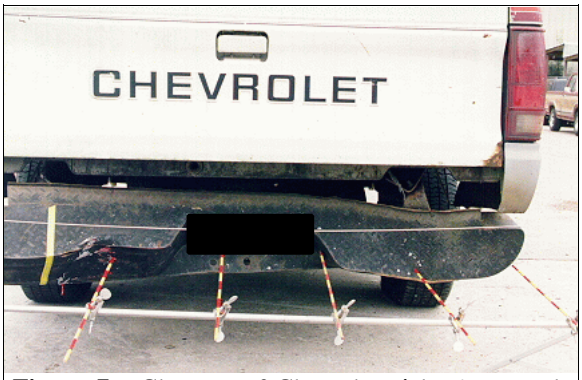

Figure 7: Close-up of Chevrolet pickup's rotated bumper which overrode front of case vehicle (case photo #58)

CASE VEHICLE

The 1994 Pontiac Grand Prix SE was a front wheel drive, five-passenger, two-door coupe (VIN: 1G2WJ12M4RF------) equipped with a 3.1L, V-6 engine and a four-speed automatic transmission. Braking was achieved by a power-assisted, four-wheel, anti-lock system. The case vehicle's wheelbase was 273 centimeter (107.5 inch), and the odometer reading at inspection was 119,690 kilometers (74,372 miles).

Inspection of the vehicle's interior revealed adjustable front cloth bucket seats with adjustable head restraints and folding backs; a non-adjustable back bench seat with integral head restraints for the back outboard seating positions; passive, door-mounted, three-point, lap-and-shoulder, safety belt systems at the front outboard seat positions; active, continuous loop, three-point, lap-and-shoulder, safety belt systems at the back outboard positions; and an active, two-point, lap belt system at the back center position. The vehicle was equipped with knee bolsters for both the driver and front right passenger which were contacted but not deformed. Automatic restraint was

provided by a Supplemental Restraint System (SRS) that consisted of a frontal air bag for the driver and front right passenger seating positions. Both front seat air bags deployed as a result of the case vehicle's frontal impact with the Chevrolet pickup.

CASE VEHICLE DAMAGE

The case vehicle's contact with the Chevrolet pickup involved approximately the left two-thirds of the Grand Prix's front bumper contacting and underriding the right two-thirds of S-10 pickup's back bumper. The Grand Prix's direct damage began 41 centimeters (16.1 inches) to the right of the front bumper's center and extended, a measured distance of 112 centimeters (44.1 inches), to the left along the front bumper (**Figures 3** and **5** above). The impact was a wide engagement and, above the bumper, extended a total distance of 40 centimeters (15.8 inches) backwards from the reference line onto the hood while at the same time compressing the front of the case vehicle downward. Adjusted for free space, the maximum crush above the bumper was measured as 18 centimeters (7.1 inches) at C_1. Part of the case vehicle's bumper fascia was peeled back (**Figure 3** above) from the plastic honeycombed bumper reinforcement while underriding the S-10 pickup's bumper. The wheelbase on the case vehicle was not shortened on either its left or right sides. The case vehicle's plastic molded, one piece, front bumper assembly (includes grille), hood, left fender and front left headlight and turn signal assemblies were all directly damaged and crushed rearward. The case vehicle's front tires were not restricted, deflated, or damaged during the crash. The right headlight and turn signal assemblies sustained induced damage as well the left fender.

Figure 8: Vertical view of case vehicle's front right passenger seating area showing contact (i.e., yellow tape) areas on deployed air bag, windshield's glazing, front right header, and roof (case photo #34)

Based on the vehicle inspection, the CDC for the case vehicle was determined to be: **12-FDEW-1 (0)**. The WinSMASH reconstruction program, damage only algorithm, was used on the case vehicle's highest severity impact. The Total, Longitudinal, and Lateral Delta V's are, respectively: 22.8 km.p.h. (14.2 m.p.h.), -22.8 km.p.h. (-14.2 m.p.h.), and 0 km.p.h. (0 m.p.h). Because of the underride-type impact, these results, although, reasonable, should be considered suspect. The case vehicle was towed due to damage.

Inspection of the case vehicle's interior revealed an oil smudge and hair in the center of the right windshield's glazing (**Figure 8**), a skin transfer on the glove compartment's door, an

indentation and hair on the front right header (**Figure 8** above), an oil smudge at the junction of the right "A"-pillar and windshield (**Figure 9**), blood drops on the roof just behind the rearview mirror (**Figure 8** above) and over the front right passenger seating area, and blood on the driver's seat cushion (**Figure 10**), particularly along the right side of the cushion near the center console near where the front right passenger's head came to rest. In addition, there was a blood smear on the driver's seat belt webbing (**Figure 10**) and left "B"-pillar that was most likely deposited by the driver after she touched the front right passenger and exited the vehicle. The windshield also was cracked from contact with the front right passenger air bag module's cover flap. The back right side of the rearview mirror was contacted by the deploying front right passenger air bag. There was no visible evidence of intrusion the case vehicle's interior.

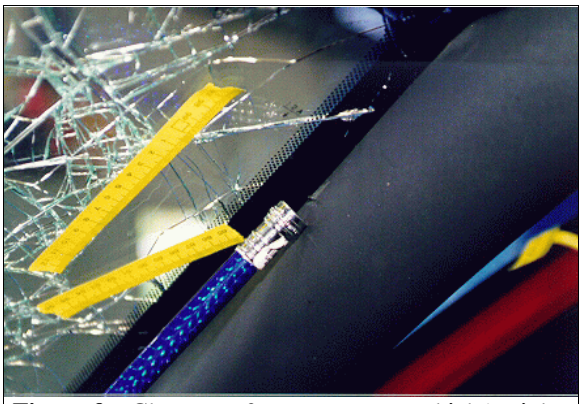

Figure 9: Close-up of gouge to case vehicle's right "A"-pillar from head of pencil's metal eraser (case photo #40)

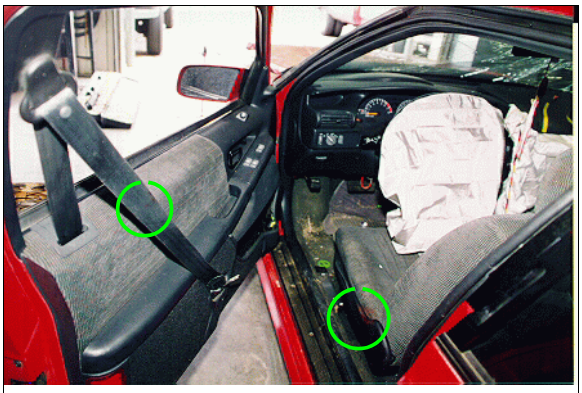

Figure 10: Interior view of case vehicle's driver seating area showing blood transfers on webbing of driver's automatic seat belt and on left side of seat cushion (Case Photo #21)

AUTOMATIC RESTRAINT SYSTEM

The case vehicle was equipped with a Supplemental Restraint System (SRS) that contained frontal air bags at the driver and front right passenger positions. Both air bags deployed as a result of the frontal impact with the Chevrolet pickup (**Figure 11** below). The case vehicle's driver air bag was located in the steering wheel hub. The module cover consisted of symmetrical "I"-configuration cover flaps made of thick vinyl with overall dimensions of 9 centimeters (3.5 inches) at the left and right horizontal seams and 10 centimeters (3.9 inches) vertically. An inspection of the air bag module's cover flaps and air bag revealed that the cover flaps opened at the designated tear points, and there was no evidence of damage during the deployment to the air bag or the cover flaps. The driver's air bag was designed without any tethers. The driver's air bag had two vent ports, approximately 2.5 centimeters (1.0 inch) in diameter, located at the 3 and 9 o'clock positions. The deployed driver's air bag was elliptical with a height of approximately 63 centimeters (24.8 inches) and a width of approximately 59 centimeters (23.2 inches). An inspection of the driver's air bag revealed a large amount of blood splatter all over (i.e., in all four quadrants) the front surface of the air bag's fabric (**Figure 12** below). These blood smears are most likely from the front right passenger when he was thrown onto the lap of the Grand Prix's driver.

Figure 11: Case vehicle's front right seating area showing deployed front air bags and contact (yellow tape) on deployed front right air bag and windshield's glazing (case photo #50)

Figure 12: Case vehicle's deployed driver air bag showing black cover flap transfers and blood splatter on part of air bag's front surface (case photo #30)

The front right passenger's air bag was located in the top of the instrument panel. There was a single, asymmetrical (trapezoidal shaped), tethered, modular cover flap. The cover flap was made of a thick vinyl over a thick cardboard type frame. The flap's dimensions were: 37 centimeters (14.6 inches) at the forward horizontal seam, 53 centimeters (20.9 inches) at the rear (i.e., toward the windshield) horizontal seam, 25 centimeters (9.8 inches) along the right vertical seam, and 32 centimeters (12.6 inches) along the angled, left vertical seam. The profile of the case vehicle's instrument panel resulted in a 3 centimeter (1.2 inch) setback of the leading edge of the cover flap relative to the protruding right instrument panel. The distance from the right instrument panel to the center of the front right seat back was 78 centimeters (30.7 inches). An inspection of the front right air bag module's cover flaps and air bag revealed that the cover flap opened at the designated tear points, and there was a scuff, a pencil indentation and what appeared to be skin on the front right air bag module's cover flap (**Figure 13**). In addition, the front right corner and right side of the cover flap contacted the windshield fracturing it and abrading the right side of the flap. The pencil tip indentation was located 6 centimeters (2.4 inches) up from the leading edge of the cover flap and 18 centimeters (7.1 inches) in from the right edge. The likely skin transfer was approximately 3 centimeters (1.2 inches) in diameter and was located 4 centimeters (1.6 inches) up from the leading edge of the cover flap and was 27 centimeters (10.6 inches) from the right edge. The scuff started at the leading edge of the cover flap 25 centimeters (9.8 inches) from the right edge and extended back 11 centimeters (4.3 inches). The front right passenger's air bag was designed with two internal tethers, each 8 centimeters (3.1 inches) in width. Both tethers were sewn to the interior face of the air bag at a point that was 10 centimeters (3.9 inches) above the bottom edge. The front right air bag had two vent ports, approximately 5 centimeters (2.0 inches) in diameter, located at the 10 and 2 o'clock positions. The deployed front right air bag

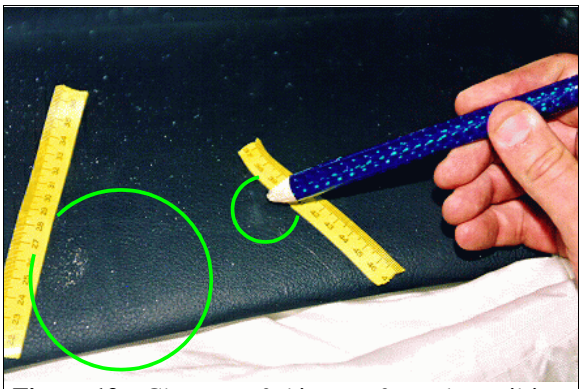

Figure 13: Close-up of skin transfer and pencil indentation on case vehicle front right air bag module's cover flap (case photo #38)

was rectangular with a height of approximately 47 centimeters (18.5 inches) and a width of approximately 70 centimeters (27.6 inches). An inspection of the front right air bag revealed a large amount of skin on the front left portion (**Figure 14**) and some transfer marks [i.e., a 2 x 6 centimeter (0.8 x 2.4 inch) black scuff] from the backside of the cover flap located to the left of the skin evidence. The skin transfer started approximately 18 centimeters (7.1 inches) down from the top edge of the air bag and extended downwards on a slight angle to the left 28 centimeters (11.0 inches). The top of the skin transfer was 4 centimeters (1.6 inches) wide and started 15 centimeters (5.9 inches) in from the left edge. The bottom of the skin transfer was 11 centimeters (4.3 inches) wide and started 10 centimeters (3.9 inches) from the left edge.

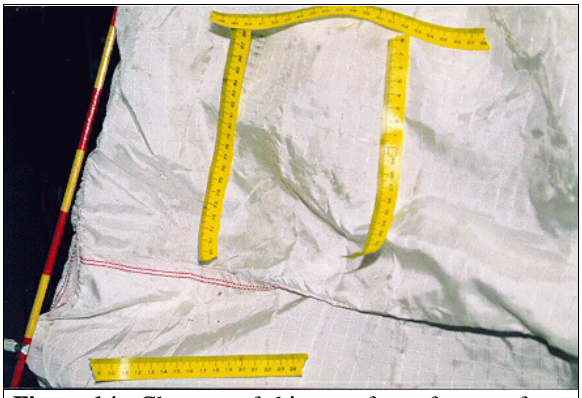

Figure 14: Close-up of skin transfer to front surface of case vehicle's deployed front right passenger's air bag from contact by front right passenger's neck (case photo #36)

CASE VEHICLE FRONT RIGHT PASSENGER KINEMATICS

According to the case vehicle's driver (i.e., sister), moments prior to the crash the front right passenger was in the process of getting up off the floor pan and turning around on the front edge of his seat so he could put on his seat belt. Immediately prior to the crash the case vehicle's front right passenger [i.e., brother of driver; 6-year-old, White (non-Hispanic) male; 124 centimeters and 22 kilograms (49 inches, 48 pounds)] was seated leaning forward on the forward-most edge of the seat cushion with his back forward of the seat back, his feet hanging down, and both arms reaching out toward the right instrument panel preparing to brace for the impact. The front right passenger was holding a children's giant, oversized pencil in his right hand just prior to the crash. The pencil point apparently contacted the cover flap as the front right passenger moved forward (**Figure 13** above), and the front right passenger may have contacted the cover flap with his hand/wrist/forearm as a result; however, there are no reported lesions consistent with cover flap interaction. The front right seat track was located between its middle and forward-most positions, and the seat back was slightly reclined.

The case vehicle's front right passenger was not using his available, passive, three-point, lap-and-shoulder, safety belt system. In addition, there was no evidence of belt pattern bruising and/or abrasions to the front right passenger's body, and the inspection of the front right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading. It should be noted that the correct restraint for a child this size is a booster seat.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of his available safety belts, the front right passenger moved forward and slightly upward just prior to impact. The damage on the case vehicle was primarily above the bumper resembling an underride impact pattern. The underride type damage resulted in the air bag deploying late during the duration of the impact. This late deployment occurred due

to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). The case vehicle's underride-type impact with Chevrolet pickup enabled the case vehicle's front right passenger to continue forward and upward as the case vehicle decelerated. Although the front right passenger attempted to brace himself with his hands just prior to the crash, the delayed deployment coupled with the front right seat's track location and the front right passenger's forward position in the seat enabled the front right passenger to be very close to the front right air bag module just prior to the deployment.

Figure 15: Case vehicle's right windshield glazing showing contacts to glazing and front right header by front right passenger's head (case photo #33a)

Based on the available injury evidence, the front right air bag module's cover flap most likely missed the front right passenger, but he contacted the front left surface of the deploying air bag, most likely with his chin and neck areas (**Figure 14** above). The deploying cover flap deflected the eraser end of the giant pencil in the front right passenger's right hand into the windshield's glazing braking off the eraser head, jamming the empty metal eraser end into the right "A"-pillar and digging into the pillar's plastic, and fracturing the pencil (**Figure 9** above). As the air bag continued to expand combined with the front right passenger's forward momentum, he was redirected slightly upward contacting the middle of the right windshield with his face and/or anterior scalp (**Figure 15**). As the air bag expanded further, the deploying air bag lifted him upwards where he contacted the windshield's front header and sun visor with the occipital area of his scalp, separating the glazing from the header (i.e., a clump of hair was stuck in the header between header and glazing–**Figure 16** and **Figure 17**). The front right passenger subsequently rebounded backwards and to his left where his head skimmed the roof, depositing a blood smear. The child most likely contacted the left side of the front right seat back before landing on the front right seat and falling leftward into the driver's lap. At final rest, the front right passenger had his head on driver's right thigh with his torso over the center console and his legs sticking out towards the right instrument panel. The passenger was removed

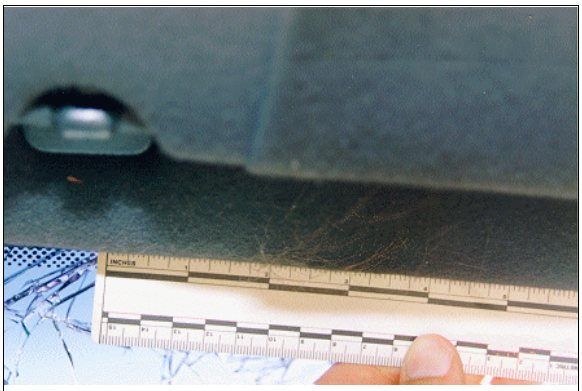

Figure 16: Close-up police photo of case vehicle's front right header showing clump of front right passenger's hair embedded in header (case photo #44)

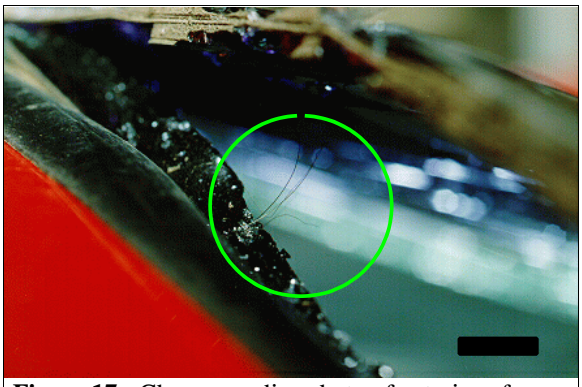

Figure 17: Close-up police photo of exterior of case vehicle's front right header area showing hair stuck between the header and separated glazing (case photo #46)

from the case vehicle through the driver's door and placed on the roadside where he was given CPR prior to the arrival of emergency medical personnel.

CASE VEHICLE FRONT RIGHT PASSENGER INJURIES

The front right occupant was transported by ambulance to the hospital. He sustained fatal injuries but was hospitalized and subsequently pronounced dead approximately nine hours post-crash. Based on this occupant's medical records (no post-mortem examination was performed), the injuries sustained by the case vehicle's front right passenger included: a laceration of his cervical spinal cord at C_2 with fracture and dislocation between C_2-C_3, a nonanatomic brain injury, a laceration (transection) of his larynx, a pneumomediastinum, fractured teeth and accompanying large full thickness laceration to his tongue, and full thickness laceration to his occipital scalp. This occupant's primary brain, neck, and fatal cervical injuries were caused by his contact with the case vehicle's deploying front right passenger air bag.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1	Laceration {transection} of spinal cord at C_2 with diastatic fracture and dislocation/subluxation between C_2-C_3 [i.e., 1 cm (0.4 in) of separation][1]	640276.6 untreatable	Air bag, front right passenger's	Certain	Hospitalization records
2	Laceration {transection} larynx	340212.5 critical	Air bag, front right passenger's	Certain	Emergency room records
3	Nonanatomic brain injury, unconscious, unresponsive, flaccid, with complications of anoxic brain injury, disseminated intravascular coagulopathy, and a hypocoagulable state[2]	160824.5 critical	Air bag, front right passenger's	Probable	Hospitalization records
4	Thoracic cavity injury, not further specified with pneumomediastinum	442204.3 serious	Air bag, front right passenger's	Certain	Emergency room records
5	Laceration tongue, large, full thickness	243400.1 minor	Windshield's right glazing	Probable	Emergency room records

[1] The radiologist described the lesion as a "distraction injury".

[2] The following terms are defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
anoxic (a-nok/sik): pertaining to or characterized by anoxia.
anoxia (a-nok/se-a): a total lack of oxygen; often used interchangeably with ***hypoxia*** to mean a reduced supply of oxygen to the tissues.
coagulability (ko-ag"u-la-bil/i-te): the state of being capable of forming or of being formed into clots.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
6	Fractured teeth[3]	251404.1 minor	Windshield's right glazing	Probable	Emergency room records
7	Laceration occipital scalp, full thickness, approximately 10 cm (3.9 in)	190602.1 minor	Windshield's front right header	Certain	Emergency room records

CASE VEHICLE DRIVER KINEMATICS

Immediately prior to the crash the case vehicle's driver [sister of front right passenger; 18-year-old, White (non-Hispanic) female; 168 centimeters and 57 kilograms (66 inches, 125 pounds)] was seated in an upright posture with her back against the seat back, her left foot on the floor, her right foot on the brake, and both hands on the steering wheel at the 9 and 3 o'clock positions. Her seat track was located between its middle and forward-most positions, the seat back was slightly reclined, and the tilt steering wheel was located in its down-most position. The case vehicle's driver was using her available, passive, three-point, lap-and-shoulder, safety belt system. The inspection of the driver's seat belt webbing, "D"-ring, and latch plate showed evidence of loading as well as blood smears on the webbing (**Figure 10** above) and near the latch plate from the front right passenger's head wound.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the use of her available safety belts, the driver leaned slightly forward against her safety belt, while bracing her arms against the steering wheel rim just prior to impact. The damage on the case vehicle was primarily above the bumper resembling an underride impact pattern. The underride type damage resulted in the air bag deploying late during the duration of the impact. This late deployment occurred due to the prolonged change in time (Delta T) relative to the change in speed (magnitude of Delta V–i.e., ramp versus spike). The case vehicle's underride-type impact with Chevrolet pickup enabled the case vehicle's driver to continue forward and upward into the deploying driver's air bag as the case vehicle decelerated. The delayed deployment coupled with the driver's seat track location enabled the driver to be very close to the

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[2] ***coagulation (ko-ag"u-la/shen)***: the process of clot formation; see *blood c*.

blood c.: the sequential process by which the multiple coagulation factors of the blood interact, ultimately resulting in the formation of an insoluble fibrin clot; it may be divided into three stages: stage 1, the formation of intrinsic and extrinsic prothrombin converting principle; stage 2, the formation of thrombin; state 3, the formation of stable fibrin polymers.

diffuse intravascular c., disseminated intravascular c. (DIC): a disorder characterized by reduction in the elements involved in blood coagulation due to their utilization in widespread blood clotting within the vessels; the activation of the clotting mechanism may arise from any number of disorders. In the late stages, it is marked by profuse hemorrhaging. Called also *consumption coagulopathy* and *defibrination syndrome*.

florid (flor/id): 1. in full bloom; occurring in fully developed form. 2. having a bright red color.

hypocoagulable (hi"po-ko-ag/u-la-bel): characterized by abnormally decreased coagulability. ***Continued***

[3] Tooth fragments were seen on X-rays in the patient's oropharynx, the cervical portion of his esophagus, and the fundus of his stomach.

driver's air bag module just prior to the deployment; however, the driver's inertia sensitive, passive, three-point restraint locked-up, restricting her forward movement. There was no apparent visible evidence of contact on the driver's air bag; although, it was surely contacted. Based on the available injury evidence, the driver contacted the front lateral surfaces of the deploying air bag with her arms. There was no evidence of compression to the case vehicle's energy absorbing shear capsules and no visible evidence of deformation to the steering wheel rim. As the air bag continued to expand, the driver rebounded straight back off the deploying air bag into her seat back. As the case vehicle came to rest, the driver was still seated essentially in her pre-crash seating position when the front right passenger's head landed on her lap. She exited the Grand Prix under her own power and sought assistance.

CASE VEHICLE DRIVER INJURIES

The case vehicle's driver was transported by ambulance to the hospital. She sustained minor injuries and was treated and released. According to her medical records, the injuries sustained by the case vehicle's driver included: abrasions and contusions to both forearms and a bruise on her right thigh.

Injury Number	Injury Description (including Aspect)	NASS Injury Code & AIS 90	Injury Source (Mechanism)	Source Confidence	Source of Injury Data
1 2	Abrasions {friction burns} volar[4] surface of both arms, location not further specified	790202.1 790202.1 minor	Air bag, driver's	Probable	Emergency room records
3 4	Contusions volar surface of both arms, location not further specified	790402.1 790402.1 minor	Air bag, driver's	Probable	Emergency room records
5	Contusion {bruise} right thigh, location not further specified	890402.1 minor	Other occupant: front right passenger	Possible	Interviewee (same person)

CASE VEHICLE BACK LEFT PASSENGER KINEMATICS

The case vehicle's back left passenger [i.e., sister of driver; 12-year-old, White (non-Hispanic) female; 155 centimeters and 42 kilograms (61 inches, 93 pounds)] was seated upright with her back against the seat back, both feet on the floor, and both hands on her lap. The seat track and seat back were non-adjustable. The back left passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back left passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the webbing or recent usage.

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[4] The following term is defined in DORLAND'S ILLUSTRATED MEDICAL DICTIONARY as follows:
volar (vo!lar): pertaining to the palm or sole; plantar; indicating the flexor surface of the forearm, wrist, or hand.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the back left passenger moved forward and slightly upward just prior to impact. In addition, she most likely extended her arms out in front of her onto the driver's seat back, trying to prevent herself from contacting the seat back and sustaining injury. The case vehicle's underride-type impact with Chevrolet pickup enabled the case vehicle's back left passenger to continue forward and upward into the driver's seat back as the case vehicle decelerated. Inspection of the Grand Prix's interior found no visible evidence of contact to the driver's seat back from this passenger's bracing and/or contact. Following the impact this passenger would have rebounded back into her seat possibly ending up on its front edge. At final rest, the exact position of the back left passenger is unknown. According to the interview with the driver, she was able to exit the vehicle without any assistance.

CASE VEHICLE BACK LEFT PASSENGER INJURIES

The case vehicle's back left passenger was driven from the scene by an older sibling. No medical treatment was sought since she did not sustain any injuries as a result of this crash.

CASE VEHICLE BACK RIGHT PASSENGER KINEMATICS

The case vehicle's back right passenger [11-year-old, White (non-Hispanic) female; 150 centimeters and 39 kilograms (59 inches, 85 pounds)] was seated upright with her back against the seat back, both feet on the floor, and both hands on her lap. The seat track and seat backs were non-adjustable. The back right passenger was not using her available, active, three-point, lap-and-shoulder, safety belt system. The inspection of the back right passenger's seat belt webbing, "D"-ring, and latch plate showed no evidence of loading on the webbing.

The case vehicle's driver braked, attempting to avoid the crash. As a result of this attempted avoidance maneuver and the nonuse of her available safety belts, the back right passenger moved forward and slightly upward just prior to impact. In addition, she most likely extended her arms out in front of her onto the front right passenger's seat back, trying to prevent herself from contacting the seat back and sustaining injury. The case vehicle's underride-type impact with Chevrolet pickup enabled the case vehicle's back right passenger to continue forward and upward into the front right passenger's seat back as the case vehicle decelerated. Inspection of the Grand Prix's interior found no visible evidence of contact to the front right passenger's seat back from this passenger's bracing and/or contact. Following the impact this passenger would have rebounded back into her seat possibly ending up on its front edge. At final rest, the exact position of the back right passenger is unknown. According to the interview with the driver, she was able to exit the vehicle without any assistance.

CASE VEHICLE BACK RIGHT PASSENGER INJURIES

The case vehicle's back right passenger was driven from the scene by an older sibling of the back left passenger. No medical treatment was sought since she did not sustain any injuries as a result of this crash.

The 1987 Chevrolet S-10 is a rear wheel drive, three-passenger, two-door pickup truck with a 7.5 foot bed (VIN: 1GCCS14R4H2------) equipped with a 2.8L, V-6 engine and a five-speed manual transmission with overdrive. Braking was achieved using a hydraulic, self-adjusting, front disc and rear drum system. This vehicle was not equipped with anti-lock brakes. The Chevrolet pickup's wheelbase was 299 centimeters (117.9 inches), and the odometer reading at inspection was 187,556 kilometers (116,542 miles).

Inspection of the vehicle's interior revealed a bench seat without head restraints; three-point, lap-and-shoulder, safety belt systems at the front outboard positions; and a two-point, lap belt system at the front center position. The front seat belt systems were not equipped with manually operated height adjusters for the "D"-rings. The Chevrolet pickup was not equipped with any Supplemental Restraint Systems (SRS).

Figure 18: Chevrolet pickup's damaged back with contour gauge present; Note: bumper rotated under truck bed allowing case vehicle to underride (case photo #56)

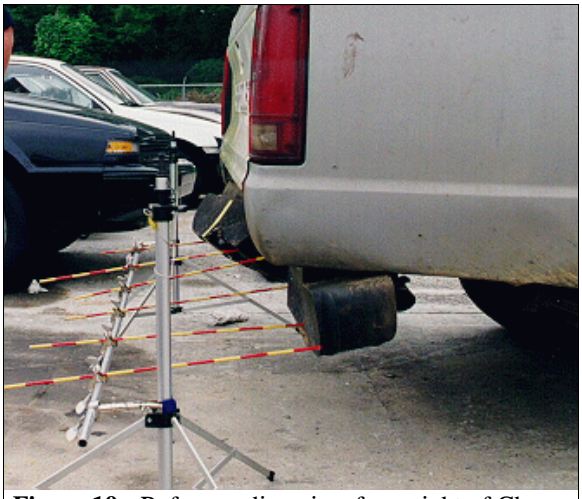


Figure 19: Reference line view from right of Chevrolet pickup's rotated bumper showing crush profile (case photo #60)

The Chevrolet pickup sustained both back and frontal impacts. The Chevrolet pickup's initial impact was to the back and involved the front of the case vehicle. Direct damage involved only the add-on rear bumper, causing it to rotate down and under the truck bed and enabling the case vehicle's front end to underride this vehicle. Direct damage began 19 centimeters (7.5 inches) to the right of the back left bumper corner and extended, a measured distance of 125 centimeters (49.2 inches) to the right bumper corner (**Figure 18**). Maximum crush was measured for the initial impact as 35 centimeters (13.8 inches) at C_5 (**Figure 19**).

The Chevrolet pickup's second impact was to its front and involved the back of the Chevrolet van. Direct damage involved both the front bumper and above the bumper. The damage above bumper showed more deformation and was concentrated primarily to the hood from impacting the spare tire attached to the Chevrolet van's rear door. Direct damage began 24 centimeters (9.4 inches) to the left of the front right bumper and extended 126 centimeters (49.6 inches) to the front left bumper corner (**Figure 20** below). Maximum crush was measured for the second impact as 4 centimeters (1.6 inches), at the bumper level, and 7 centimeters (2.8 inches)

to the hood. The Chevrolet pickup's front bumper, hood, and front grille were all deformed as a result of the second impact this vehicle sustained.

Figure 20: Chevrolet pickup's frontal damage from impacting back of Chevrolet van; Note: yellow tape indicates end of direct damage (case photo #64)

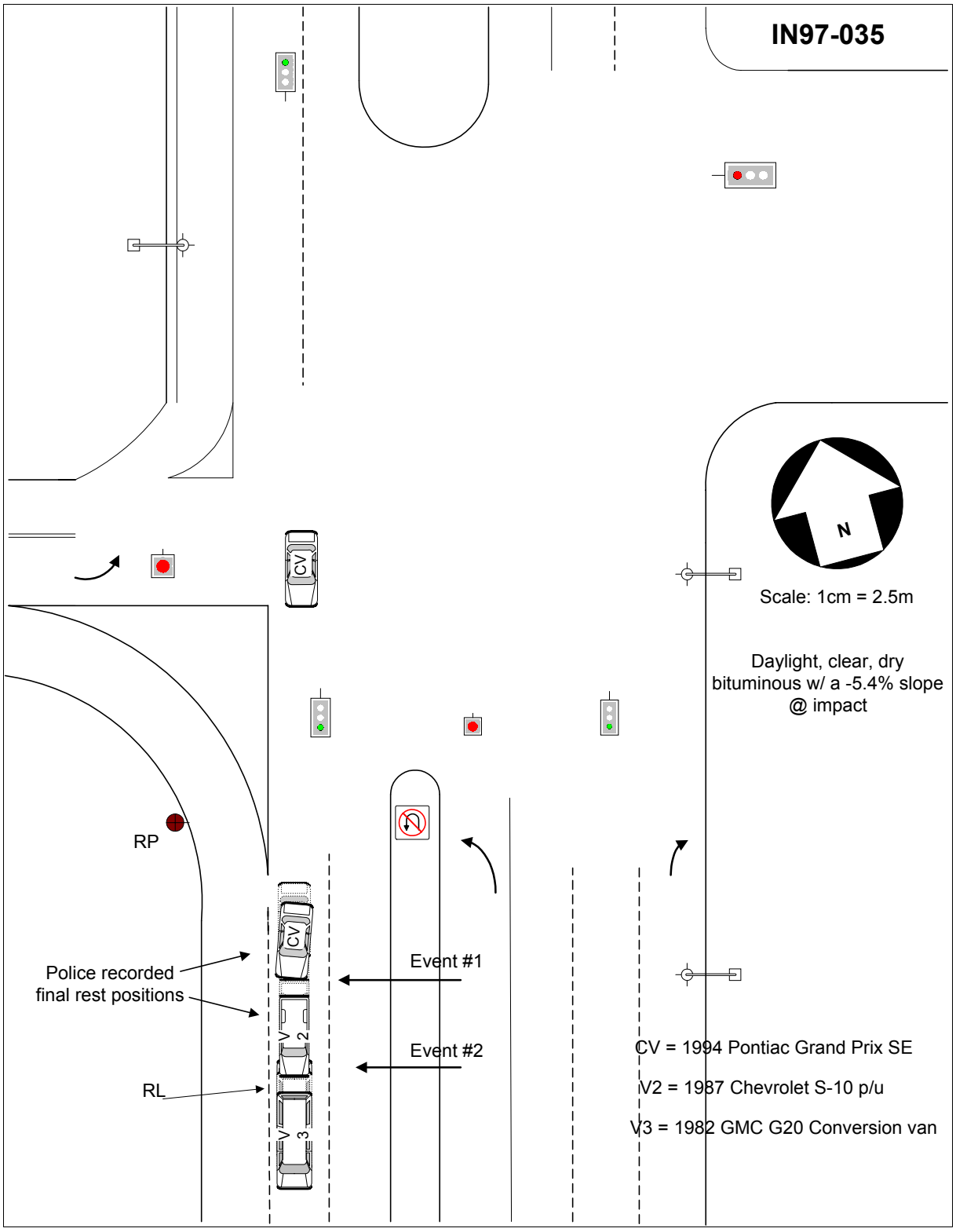
Based on the vehicle inspection, the CDCs for Chevrolet pickup were determined to be: **06-BDLW-1 (180)** and **12-FDEW-1 (0)**. The WinSMASH reconstruction program, damage only algorithm, was used on the Chevrolet pickup's highest severity (i.e., initial) impact. The Total, Longitudinal, and Lateral Delta V's are, respectively: 28.9 km.p.h. (18.0 m.p.h.), +28.9 km.p.h. (+18.0 m.p.h.), and 0 km.p.h. (0 m.p.h). The Chevrolet pickup was towed due to damage.

2ND OTHER VEHICLE

The 1982 Chevrolet G-20 is a rear wheel drive, ¾-ton, full sized conversion van (VIN: 1GCEG25H2C7------) equipped with a 5.0L, V-8 engine and a three-speed transmission; however the transmission type is unknown (i.e., manual versus automatic). Braking was achieved by a power-assisted, hydraulic, self-adjusting, front disc and rear drum system. Anti-lock brakes were not available for this model. The Chevrolet van's exact wheelbase and the odometer reading at inspection are unknown because the Chevrolet van was not inspected.

Figure 21: On-scene photo of Chevrolet van's final rest position in southbound merge lane; Note: damage limited to left rear door and spare tire (case photo #69)

The Chevrolet van sustained an impact to its back from the front of the Chevrolet pickup. Based on the on-scene police photograph, there was no apparent visible damage but, presumably, the left rear door where the spare tire was attached to it was deformed (**Figure 21**) The maximum crush was estimated to be 3 centimeters (1.2 inches). Based on the available photographs, the CDC for Chevrolet van was determined to be: **06-BYMW-1 (180).** The Chevrolet van was driven from the scene.


IN97-035
N
Scale: 1cm = 2.5m
Daylight, clear, dry
bituminous w/ a -5.4% slope
@ impact
CV
RP
Police recorded
final rest positions
RL
Event #1
Event #2
V2
V3
CV = 1994 Pontiac Grand Prix SE
V2 = 1987 Chevrolet S-10 p/u
V3 = 1982 GMC G20 Conversion van